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ABSTRACT

Computer applications that facilitate the use of the World Wide Web (WWW) within elementary and secondary education must provide support for educators to locate materials quickly and easily; they must minimize the amount of time spent waiting for files to traverse the network; and they must deal sensitively with censorship. The MicroWeb Toolkit is designed to provide software tools to organize and present educational information using WWW resources. The MicroWeb Toolkit assists with the construction and organization of resource collections rather than with the authoring of individual pages by providing tools to organize and classify WWW resources around a specific topic. A MicroWeb collection is designed to minimize the cognitive overhead of the user and to reduce network traffic through resource caching. Topics discussed include using hypermedia collections; features of the MicroWeb Toolkit; creating a MicroWeb collection from the developer and teacher/trainer viewpoints; and conclusions and plans for future development. A diagram illustrates the components of the MicroWeb Toolkit. (Author/DLS)

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The MicroWeb Toolkit: Bringing the WWW to the Classroom

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Abstract: Computer applications that facilitate the use of the World Wide Web within elementary and secondary education must provide support for educators to locate usable materials quickly and easily; they must minimize the amount of time spent waiting for files to traverse the network; and they must deal sensitively with censorship. The MicroWeb Toolkit is designed to provide software tools to organize and present educational information using World Wide Web resources. The MicroWeb Toolkit assists with the construction and organization of resource collections rather than with the authoring of individual pages by providing tools to organize and classify WWW resources around a specific topic. A MicroWeb collection is designed to minimize the cognitive overhead of the user and to reduce network traffic through resource caching.

1. Introduction

Computer applications that facilitate the use of the World Wide Web within elementary and secondary education must provide support for educators who need to locate usable materials quickly and easily; they must minimize the amount of time spent waiting for files to traverse the network; and they must deal sensitively with censorship. The application must also support the hypermedia nature of the Web, preserving structure whenever possible. The MicroWeb Toolkit facilitates the organization and classification of Web resources into topic-specific collections. Each collection consists of a series of concept pages and example pages. The concept pages are created by the collection developer using a concept map and the examples are resources found or placed on the World Wide Web. While using a collection, the learner is in control of pacing and browsing sequence but the educator has ultimate control of the material presented and how that material is linked to the concepts. When using the collection, learners view many different examples of concepts and gradually construct a personal understanding of the material.The process of creating concept maps, finding resources, and constructing the collection is time consuming, even with good tools. Fortunately the end result can be an extremely portable set of reference materials that can be shared widely. Although anyone, even children, could create MicroWeb collections, the MicroWeb Toolkit has been designed primarily to allow a "subject expert" to create collections for a particular topic and then supply those collections to teachers of that topic. Collections are usable on computer systems that can support a graphical Web browser. Teachers will not have to learn to use the MicroWeb Toolkit in order to benefit from the collections created by it because they can borrow entire collections, or parts of collections, from other educators.

2. Using Hypermedia Collections

The Web provides flexible access to unlimited amounts of material but, as with any form of hypermedia, the use of the Web is not without difficulty. For example, communications over the internet are frequently slow yet it is difficult to minimize the network traffic because there is no database management system for the Web. Automating resource updates is impossible because the location of copies of Web pages cannot be determined. The most frequently discussed problem that users of hypermedia resources encounter is a feeling of disorientation often referred to as being *lost in hyperspace* [Balasubramanian 1993]. Users who become lost need help to retain a sense of context about the material. The effort of maintaining this context while browsing a hypermedia resource has been

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called cognitive overhead [Thuring et al. 1995].Often users of the Web have difficulty finding useful material. A user must sift through much irrelevant material before finding the nuggets of information that match his or her interest. If the hyperlinks within the resource do not reveal to the user where the desired information is located, the resource lacks information coherence any may further impede the user's efforts to find information.To make the Web a usable tool for education, the issues of cognitive overhead and coherence must be addressed. Additionally, educational users of the Web must have methods to ensure that learners work with information that is suitable. Cognitive overhead can be reduced by providing navigational support as well as ensuring a consistent user interface. A coherent resource collection will allow the user to construct an accurate mental of the topic. The collection coherence can be increased by providing an overview of the hypermedia collection that shows the structure of the collection information [Thuring et al. 1995]. Any utility that gives the user an overview of the resource space surrounding the current position in the hypermedia resource can be classified as an overview diagram [Catledge and Pitkow 1995]. Overview diagrams can orient users to the surrounding hyperspace and to the content organization, affecting both cognitive overhead and coherence. In order to provide information about the hyperspace, the navigational tool must have access to information about hyperlinks. Usually this link information is stored in a database separate from the hypermedia system and the database is used to create the overview [Andrews et al. 1995; Roescheisen et al. 1995].Information about a hypermedia collection can also be communicated through annotations. An annotation is text or graphics added to a hypermedia resource with the intent of conveying extra information to the user. The most common form of annotation for World Wide Web hypermedia resources is the personal bookmark file, or hotlist. Annotations become more useful when they can be shared with other users such as through a trail or system of landmarks. Another method of sharing is to create and maintain a database of annotations provided by a particularly type of expert user. This database can then be accessed by users to find out what others have to say about a resource. The information in the annotation database could also be used to create tours and trails [Roescheisen et al., 1995; Andrews et al., 1995].An adaptive annotation system provides individualized information about a node to specific users [Brusilovsky, in press]. Adaptive annotation techniques could provide useful navigational aids for hypermedia collections by changing the annotations presented to suit the needs of the user. Users are presented with a stable view of the hypermedia application and are free to navigate the hyperspace in any fashion but navigational support is present at all times. Adaptive annotations can be something as simple as different colors for links or a complicated system that ranks resources in the collection based on resource position and content and annotates the collection based on the ranking [Tomek and Maurer, 1992].

3. The MicroWeb Toolkit

The MicroWeb toolkit is designed to provide software tools to organize and present information using World Wide Web resources. Many software packages are available for use by WWW information providers and most provide support only for the creation of individual Web pages. The MicroWeb toolkit assists with the construction and organization of resource collections rather than with the authoring of individual pages. The MicroWeb toolkit enables educators to present coherent hypermedia collections to learners using standard WWW browsers. The hypermedia collections, referred to as MicroWeb collections, can be presented either as a stand-alone hypermedia resource from which the learner may not stray, or as an application that allow connections to the larger World Wide Web.A learner uses a MicroWeb collection either by connecting to a special proxy HTTP server, or by loading collection documents from a local disk. From the initial collection document, the learner may select hyperlinks to navigate through the MicroWeb collection. The MicroWeb toolkit adds a header to each resource in the collection to give the learner extra information about the resource and the collection. The learner may, at the teacher's discretion, view Web pages that are not part of the MicroWeb collection. Clearly identified non-MicroWeb pages contain the standard MicroWeb header including a hyperlink back to the most recently viewed collection page. The learner may read through any resources in the collection, view pictures and animation sequences, and listen to sound recordings, all at an individual pace. The learner may make notes (annotations) about any of the resources which are stored for future reference. Annotations added to resources within the collection can assist the learner to navigate through the material. For learners who wish to find specific material, a table of contents is available for the collection in the form of a hierarchical concept map. The concept map allows the learner to see how

sub-topics are related to one another as well as provides the learner with an overview of the entire concept. The learner gradually constructs his or her own understanding of the collection topic by reading, viewing, and listening to the material.

4. Creating a MicroWeb Collection

The components of the MicroWeb Toolkit are grouped into three modules. Two of the modules, the Resource Collection Proxy and the Collection Viewing Proxy function as proxy HTTP servers implemented using the STRAND toolkit [Brooks et al 1995]. The third module, the MicroWeb Control Environment allows the developer to organize and modify the collection. Educators who wish to create MicroWeb collections can benefit from a variety of components, including: a *Resource Collector*, a *Compiler/Interpreter*, an *Annotator*, a *Concept Mapper*, a *Learner Monitor*, an *Access Controller* and a *Collection Manager* [Figure 1]. Each component communicates with the MicroWeb database, which stores the MicroWeb representation of the resource collection. The information in the database includes meta-information about each WWW resource in the collection, links between collection resources, a representation of each of the concepts for the collection, and information about users of the collection.

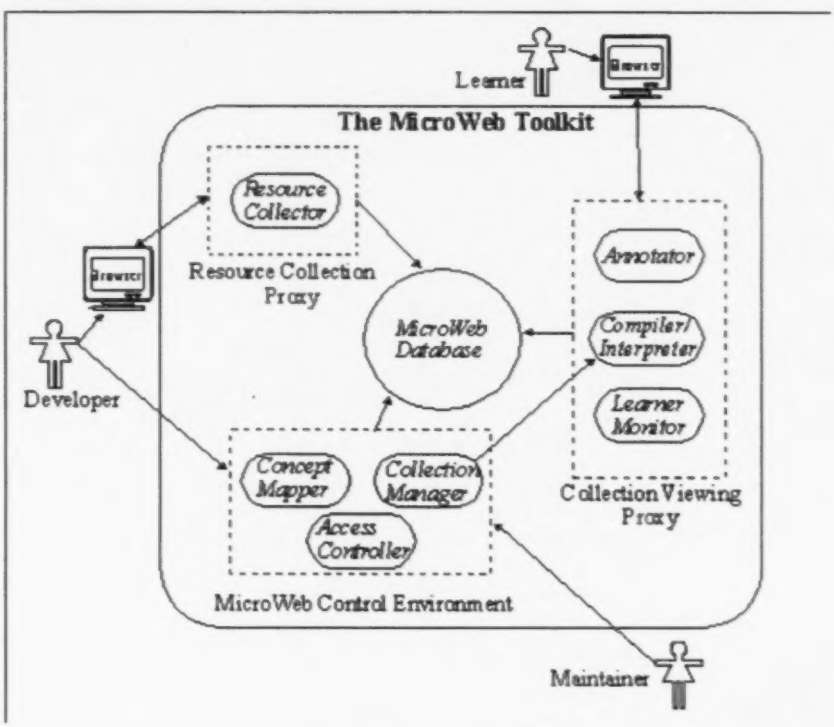

Figure 1 The MicroWeb Toolkit

4.1 Developer viewpoint

A MicroWeb collection cannot be created without resources and likewise cannot be created without a concept map to provide some organization to the collection. It is a matter of individual preference whether the first step is to find Web resources or to develop the concept map. In reality it is more likely that the developer will move between the two tasks until both are completed. The *Concept Mapper* allows the MicroWeb developer to gradually refine a diagram of the concepts to provide an abstract model of the general topic similar to the approach of [Zhao and Patel 1995]. The concept map for a new collection is begun by entering keywords to label the concepts to be included. The concepts are manipulated and moved around much as one would manipulate information within an outline for a document. Unlike typical outlining tools, the MicroWeb concept mapping tool allows concepts to be

connected to other previously defined concepts within the outline. The result of the concept mapping process is a network-like description of the concepts for the MicroWeb collection. A graphical representation of MicroWeb concept maps becomes the primary interface between the developer and the concept mapping tool. At any point during concept mapping the developer may begin (or resume) collecting resources. Resources are simply Web pages or files that reside somewhere on the World Wide Web. They may be authored by the developer or by someone else. Resources are collected using a Web browser connected to the Resource Collection Proxy, which uses the *Resource Collector* component. The proxy server inserts an additional hyperlink into each resource to allow the addition of Web pages to the MicroWeb collection. Enough information about the resource is added to remind the developer of its contents and title. It is the responsibility of the developer to ensure that the original authors of the Web pages are amenable to having their resources included in the MicroWeb collection. The developer works alternately with the *Resource Collector* and the *Concept Mapper* to match the found resources to concepts in the map. The collected resources are linked into the MicroWeb collection using the concept map as a guideline for creating linkages. At first, each resource is linked only to relevant nodes in the concept. As the developer adds connections to the collection, linkages can be created between resources as well as between concepts in the database. For each resource the developer moves an icon representing the resource to the concept (or concepts) to which it corresponds. The linking process is very much like moving files around in a graphical file management program. As the map is adjusted by the developer, the *Concept Mapper* adjusts the database representation of the MicroWeb collection [Philip 1996]. Once the developer is satisfied that all of the available resources are linked to appropriate concepts, it is possible to ask the *Collection Manager* to analyze and check the consistency of the collection. The analysis detects concepts for which there are too many linked resources (indicating that some subdivision is likely desirable) or for which there are too few resources. It also checks that resources are sufficiently connected to the rest of the collection. When the developer is finished, the collection can be used. The developer can choose to create a collection that requires no internet access by using the *Compiler* or can create either a cached or direct-access collection using the *Interpreter*. A cached collection requires only intermittent access to the World Wide Web to update documents, while a direct-access collection always accesses the Web and retrieves the most recent version of documents. Finished collections can be viewed by connecting a Web browser to the Collection Viewing Proxy.

4.2 Teacher/Trainer Viewpoint

Although it is possible that the developer of a MicroWeb collection will also be the teacher using the collection, it is anticipated that frequently the developer and teacher will be two different people. Some of the features of the MicroWeb toolkit are designed specifically for the use of the teacher who uses MicroWeb collections for instructional purposes.It is essential that the teacher or collection designer be able to communicate additional information about the pages in the MicroWeb collection to the learners using the collection. Since the collections can be used independently, it is necessary for that communication to happen asynchronously. Annotations can provide an appropriate method for this kind of communication. After the collection is created, the teacher may use the *Annotator* component to add annotations to any of the resources in the collection through an HTML form similar to an email form. When an annotation is added, information about the person making the annotation, the MicroWeb resource, and the text of the annotation is stored as part of the database representation of the collection.Several factors determine how much control a teacher needs over learner access to the World Wide Web. Learners who are new to the Web environment will likely be more productive in their initial experiences if the hyperspace they can explore has definite boundaries. Similarly, learners who are not mature enough to judge the suitability of Web resources for their purposes can benefit from restricted access to the World Wide Web. Learners with more experience and maturity may benefit from some guidance, but likely would be able to manage working through the entire hyperspace of the WWW. The teacher uses the *Access Controller* to set access limitations for learners. Three levels of access are possible from a MicroWeb collection: denied, semi- restricted and unrestricted. Learners for whom outside access to the WWW is denied may view only those resources that are part of the MicroWeb collection. Learners with semi-restricted access to the Web are allowed to view other Web pages from selected portions of the Web. Semi-restricted learners may browse through particular resource hierarchies on specific Web sites but not jump to pages that are part of a different Web site. The site-based restriction allows the learner to thoroughly inspect a Web site that the educator has deemed appropriate without travelling too far into the Web. Unrestricted Web access allows users to view any

non-collection WWW pages but the toolkit provides a hyperlink within the MicroWeb header allowing the user to quickly return to the MicroWeb collection. As learners work with a MicroWeb collection, records can be kept of the pages that a learner examines and the time spent on them. Teachers may view these records for evaluation or planning. The records allow teachers to retrace the path of individual learners through the MicroWeb. The teacher may define a list of required pages for specific learners to examine or recommended traversal paths. The MicroWeb toolkit can use the learner records and these lists to make suggestions about which pages the learner should look at. In this way learners can be guided into looking at specific portions of a MicroWeb. This feature is the focus of a related project [Philip 1996]. MicroWeb resources can be cached locally to reduce the need to connect to the Internet and the time spent waiting for resources to be retrieved. While this feature reduces the cost of connection and network traffic, it may present problems when the original author changes the resource. As resources in their original location are modified, the MicroWeb collection will become increasingly outdated. The *Collection Manager* component can automatically check for updated documents. When an update check is performed, the *Collection Manager* checks the original location of each resource in the collection to see if the original has been modified. The teacher is notified of any modified resources and can decide if the modified resource should replace the original in the collection.

5. Conclusions

The design of the *Resource Collector*, *Compiler/Interpreter*, *MicroWeb database* and *Concept Mapper* has been completed. Preliminary design is in place for the *Annotator* and *Access Controller*. Prototypes of the Resource Collection Proxy, Collection Viewing Proxy, and the MicroWeb database have been created and tested on a sample resource collection. The *Concept Mapper* and the *Learner Monitor* are under development as part of a related research project. It is intended that field testing of sample MicroWeb collections will begin soon, using a locally cached collection. The entire MicroWeb Toolkit will be tested for functionality upon completion of the components. Plans are underway to develop metrics that facilitate the evaluation of MicroWeb resource collections. We anticipate that the complete MicroWeb Toolkit will simplify the process of organizing WWW resource collections. It will provide tools for structuring concepts and organizing Web resources within that structure. The resulting collection should be coherent and have several different navigational tools to support learners. The toolkit allows educators to take advantage of the resources on the WWW while providing solutions to many of the problems that arise when using the Web. Learners will not become lost using a MicroWeb collection because navigational support is always present, yet they will gain valuable experience using hypermedia collections. Educators can use MicroWeb collections built by others, which can reduce both the teacher time spent finding the resources and the network time consumed by retrieving the resources. Finally, educators are assured that learners will remain on topic and view only appropriate material.

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